Progress report and current status of CFHT's spectropolarimeter ESPaDOnS

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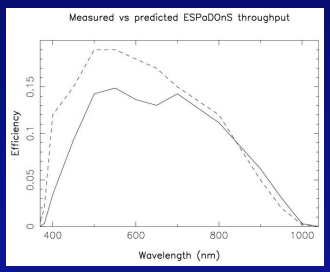
Abstract: Since ESPaDOnS's installation at CFHT in the Fall of 2004, a few technical issues have been identified and worked on. The source of the lower-than-expected throughput has not been found. The current level of cross-talk is 2-3%, still acceptable by the communities, but there is a desire to lower that level to less than 1%. The lower-than-expected spectral resolution has not been solved and still needs to be worked on. The detector work on EEV1 is done, after improving the grounding and thermal regulation, and investigating the smearing on saturated pixels. Current work includes an automatic f/8 telescope focus model and control, along with plans to move ESPaDOnS into the Queued Service Observations mode.

Since the very beginning, ESPaDOnS has been a very successful, user-friendly, easy-to-maintain, and basically trouble-free instrument, with a very high demand and high level of satisfaction from PIs. CFHT and Observatoire Midi-Pyrénées are still working on remaining technical issues, to maximize the scientific return from this unique instrument.

Efficiency / Throughput

- On-sky engineering initial assessment [Fall 2004]:
  - *the instrument is less efficient in the blue (by typically 20% below 600nm)*
  - *there is an additional 20% loss over the whole spectral domain*
- Fibers damaged while installed at the telescope introduced a loss of about 1 mag [Jan – Jun 2005], while replacement spare fibers produced a loss of 0.4 mag [Jun 2005 - Feb 2006]



- New fiber bundles and new connectors installed in June 2006 brought the throughput back to its late 2004 level
- On the operational side, improved methods are being sought to improve the fiber to pierced mirror alignment accuracy and repeatability. The actual adjustments, however, remain challenging since motions on the order of a micron are noticeable. For repeatability, one new fiber mount was tried, but was found to be no more repeatable than the current mount.

The source of the lower than expected throughput has not yet been found. Improved fiber mounts and alignment method will help minimize any loss of light due to re-installing the fibers before each ESPaDOnS run.

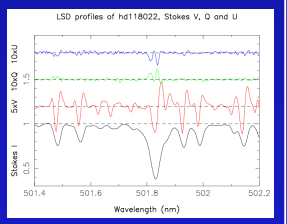
Cross-talk

During engineering and commissioning, the instrument behaved as expected when measuring circular polarization: the Stokes V signatures from well-known magnetic Ap stars agreed with values published in the literature. However, Zeeman signatures in linear polarization contained a significant fraction (about 20%) of circular polarization, indicating the presence of crosstalk from V to Q and U (and vice versa).

The cause was identified and attributed to the first triplet lens within the polarimeter (located above the polarization module). When cold, the lens's barrel contracts and produces stress birefringence in the glass (seen as a dark cross above).

A first replacement lens was installed in June 2005, but 7-8% cross-talk still remained. A second replacement was installed in June 2006, lowering the cross-talk to 2-3%.

Data now show that a strong circular polarization signal at 502nm (graph at right, in red) does not leak in the linear polarization Stokes parameters Q and U (in green and blue).



From a survey of the CFHT communities, a 2-3% cross-talk is acceptable for now, but there is a desire to decrease this level to below 1% so that other programs can be carried out. For this to happen, a new manufacturing process is probably needed.

Spectral resolution

ESPaDOnS's spectral resolution is significantly lower than the expected one (NARVAL, ESPaDOnS's twin installed at the Pic-du-Midi observatory, exhibits the same problem). Part of the problem might be due to the CCD (EEV1), because an engineering chip used during the engineering run had slightly better resolution (still well below the theoretical one). Optical problems in the spectrograph have been ruled out: masking the beam to only keep the central portion of the pupil reveals nominal optical aberrations. An investigation of the smearing seen on saturated Thorium lines has also concluded that the spectral resolution does not improve when the smearing is minimized.

Observing Mode	Polarimetry	Spectroscopy Star + Sky	Spectroscopy Star Only
Theoretical Spectral resolution	70k – 75k	70k – 75k	90k – 100k
Measured Spectral resolution	63,000	63,000	75,000

Ongoing investigations of the spectral resolution use a Zemax model of the instrument and planned measurements made with a detector with smaller pixels.

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